Note on William Ball's Observations of Saturn.

By Prof. J. C. Adams, M.A., F.R.S.

In No. 9 of vol. i. of the *Philosophical Transactions*, a brief account is given of an observation of *Saturn* made on Oct. 13, 1665, at 6 o'clock, by William Ball, at Mamhead, near Exeter, and it is suggested that the appearance presented by the planet may perhaps be caused by its being surrounded by *two* rings instead of *one*.

This account has recently given rise to considerable discussion; and there are some difficulties connected with it which do not appear to have been satisfactorily cleared up. In a few copies of the volume this account is illustrated by a figure, in which the external boundary of the ring, instead of being of a regular elliptical form, has two blunt notches or indentations at the extremities of the minor axis. The plate containing this figure, however, is wanting in by far the larger number of the copies.

Now, I think, it may be safely asserted that no telescope, capable of showing *Saturn's* ring at all, ever exhibited it in this extraordinary form, and therefore if the above figure faithfully represents William Ball's drawing, he was either a very inaccurate and careless observer, or he must have been provided with very inadequate instrumental means.

On the other hand, we have ample proof that he was a careful and assiduous observer, that in particular he made a long series of observations of *Saturn*, and that these were made with instruments not much inferior to those employed by Huyghens himself in similar observations.

It is well known that Huyghens's discovery of the true nature of the appendage to *Saturn*, which had so puzzled Galileo and others, was contested by Father Fabri at Rome, who wrote under the name of "Eustacius de Divinis."

Huyghens replied to Fabri's objections in a tract which appeared in 1660, entitled *Brevis Assertio Systematis Saturnii sui*, and which is contained in the third volume of his collected works.

In this tract he repeatedly appeals to Ball's observations in England in confirmation of his own. It is clear that Huyghens was in possession of drawings by Ball which represented the various appearances presented by the planet during the four years from 1656 to 1659 inclusive, and that he had carefully compared them with those which he had himself taken during the same interval. After mentioning the dark band which he had observed on the disk of *Saturn* at times when the remainder of the ring was invisible, he quotes a letter from Dr. Wallis, dated Dec. 22, 1658, in which reference is made to an earlier letter dated May 29, 1656, wherein Dr. Wallis had mentioned this band as having been observed by Ball, and had inquired whether his correspondent had likewise perceived it. Huyghens goes on to say that from Feb. 5, 1656, to July 2, when the planet appeared round

and without ansæ, this band or dark shading was observed by Ball to cross the centre of the disk, as shown in his drawing, exactly as in Huyghens's own figure.

Afterwards, when the ansæ had re-appeared, the band was seen with more difficulty, and its position was less accurately laid down in Ball's drawing. From Nov. 5, 1656, to July 9, 1657, when the oblong arms of *Saturn* were seen apparently united to the disk, Ball gives a figure quite similar to that of Huyghens, except that he makes the arms a little thicker.

Again, from Nov. 9, 1657, to June 7, 1658, when the arms were more open, Ball's figure is exactly similar to Huyghens's, except a slight difference in the position of the obscure zone or belt.

Also, finally, the same remark applies to the figure of the planet from Jan. 3, 1659, to June 17 of the same year, when the ansæ were a little more widely opened.

Having made these comparisons between Ball's drawings of the planet and his own, Huyghens remarks that Ball was unacquainted with his hypothesis* (respecting the ring), and therefore could not be supposed to be biased by it, while he himself would not dare to represent the phenomena otherwise than they really were, since, if he did, he might at once be contradicted by the English observer.

This judgment of so competent an authority as Huyghens, made while he had before him all the materials for forming it, left no doubt on my mind as to the merit of Ball's observations.

In order to see whether any further light could be thrown on the subject, I have recently taken an opportunity of consulting the MSS. preserved in the archives of the Royal Society.

Among them I find there is a letter in William Ball's own hand, dated April 14, 1666, in which he makes reference to his observations of *Saturn*, although the greater part of the letter relates to other subjects. He mentions that the observations were made partly with a telescope thirty-eight feet in length, having a double eye-glass, and partly with another telescope twelve feet in length. In the postscript to this letter he gives a small sketch of *Saturn* as it appeared at that time (1666), and he mentions that the same appearance was presented by the planet in 1664. In this figure the external boundary of the ring has the form of a regular oval, without any notches or other irregularities.

No allusion is made to the very different appearance which, if the figure in the *Philosophical Transactions* is authentic, the planet must have presented in 1665.

It should be understood that the paper in the *Philosophical Transactions* which is now in question was not written by Ball himself. It contains, however, a quotation from a letter of Ball to a friend (probably Sir R. Moray), and in what appears to be

* Huyghens's *Systema Saturnium* only appeared in 1659.

the last clause of this quotation, the figure is said to be "a little hollow above and below." I cannot help thinking that this clause has been added or altered in some way to correspond with the given figure. The letter of Ball on which this paper was founded is not in the archives; but there is preserved, not a drawing, but a paper cutting, representing the planet and its ring, which is no doubt the original of the figure engraved in the *Transactions*.

The defect in the paper cutting probably originated in the following way. In order to make the cutting, the paper was first folded twice in directions at right angles to each other, so that only a quadrant of the ellipse had to be cut.

The cut started rightly in a direction perpendicular to the major axis, but through want of care, when the cut reached the minor axis, its direction formed a slightly obtuse angle with that axis instead of being perpendicular to it.

Consequently, when the paper was unfolded, shallow notches or depressions appeared at the extremities of the minor axis.

I imagine that the account in the *Philosophical Transactions* was written by some one inexperienced in astronomical observations, who took for granted that the figure was correct. The mistake being soon discovered, the plate which contained the erroneous figure of *Saturn*, together with two other figures relating to different subjects, was cancelled, and thus its appearance in only a few of the copies is accounted for. The other figures on the cancelled plate were repeated in a new plate which accompanied No. 24 in the same volume of the *Transactions*.

In Lowthorp's abridged edition of the *Transactions* the figure of *Saturn* has been corrected.

I find no evidence that Ball, any more than Huyghens, had noticed any indication of a division in the ring.

It may be interesting to give the original text of the passages of Huyghens's *Brevis Assertio Systematis Saturnii sui*, in which reference is made to Ball's observations.

The citations are taken from the third volume of Huyghens's *Opera Varia*, edited by 'S Gravesande, and published at Leyden in 1724.

"Credo et fasciam nigricantem in *Saturni* disco, liquido sibi conspici dixisset Eustacius, ni Fabrio visum fuisset eam nimium hypothesi meæ annullari favere. Cum autem ne optimis quidem suis perspicillis eam cerni affirmet, hinc quoque quanto illa meis deteriora sint perspicuum sit. Nam ne mihi phenomenon illud confictum credatur, idem et in Anglia pridem observari cœpisse sciendum est; et liquet ex literis viri clar. Joh. Wallisii, Oxonia ad me datis 22 Dec. 1658, quibus inter alia hæc scribit. *Monebam etiam iisdem literis* (nempe *datis* 29 *Maji* 1656) *de Saturni fascia quam jam ante observaverat D. Ball, et sciscitabar num tu eandem conspexeras*, &c. Eam porro fasciam à 5 Feb. 1656 ad 2 Jul., quo tempore rotundus *Saturnus* absque ansis apparuit, medium planetæ discum secare D. Ball adnotavit, ut in schemate ad me misso expressa est. Atque ita mihi quoque

fuerat eo tempore observata, ut cernitur pag. 544 *Systematis Saturnii*, quam figuram hic repeto. Postmodum tamen renatis *Saturni* ansis cum difficillimè conspici eadem fascia cœpisset, minus rectè quoque a D. Ball, quantum ad situm attinet, depicta est. At in mearum observationum adversariis, die 26 Nov. 1656, et alias adscriptum invenio, lineam obscuram fuisse evidentissimam, eo nempe positu, qui pag. 545 *System. Saturnii* memoratur."—Pp. 624, 625.

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"Non ægre nunc fidem habitum iri spero, tum mihi tum Anglis simul observatoribus, qui anno 1657 oblonga *Saturni* brachia disco utrinque conjuncta spectavimus, qualia exhibet figura *Systematis* mei pag. 545, quam hic repono; non autem binorum orbiculorum formâ a medio disco disjunctorum, ut Eustacius se illa eodem tempore vidisse dejerat. Adderem hic schema quod mihi à D. Ball, supra memorato, advenit, nisi planè simile esset huic nostro, hoc uno tantillum duntaxat abludens, quod brachia illa ubique paullo crassiora ille referat.

"Eam vero formam a 5 Nov. 1656 ad 9 Jul. 1657 sibi apparuisse scribit. Apertis autem brachiis, qualis pag. 547 *Systematis* mei et hic representatur, talem à 9 Nov. 1657 ad 7 Jun. 1658, idem observator depingit, simillima prorsus figura, nisi quod ad positum zonæ obscuræ attinet, de quo dixi suprà. Ac denique à 3 Jan. 1659 ad 17 Jun. ejusdem anni, ansis paulo latius adhuc apertis. Et hæc quidem ille, ignarus adhuc meæ hypotheseos, ne ob præconceptam opinionem aliquid indulsisse sibi existimetur. Neque ego aliter quam se revera habent referre auderem, cum redarguere me, si fallam, autori observationum in promptu sit."—P. 626.

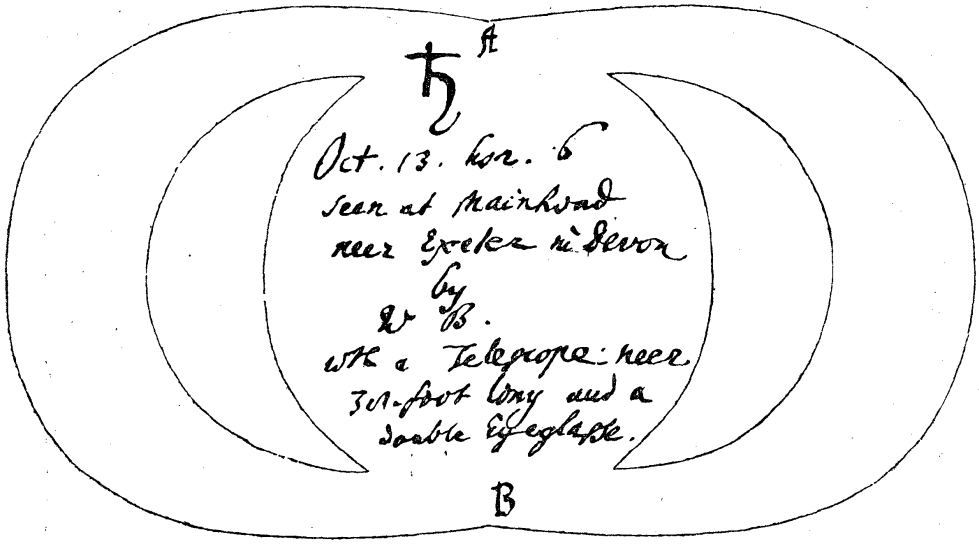
The following extract comprises all that is material in the Paper in the Philosophical *Transactions*:—

"This observation was made by Mr. William Ball, accompanied by his brother, Dr. Ball, October 13, 1665 at six of the Clock, at Mainhead near Exeter in Devonshire, with a very good Telescope near 38 foot long, and a double Eye-glass as the observer himself takes notice, adding, that he never saw that planet more distinct. The observation is represented by Fig. 3 concerning which, the Author saith in his letter to a friend, as follows, This appear'd to me the present figure of Saturn, somewhat otherwise, than I expected, thinking it would have been decreasing, but I found it full as ever, and a little hollow above and below. Whereupon the Person, to whom notice was sent hereof, examining this shape, hath by letters desired the worthy Author of the *System of this Planet*, that he would now attentively consider the present Figure of his Anses, or Ring, to see whether the appearance be to him, as in this Figure, and consequently whether he there meets with nothing that may make him think, that it is not *one* body of a circular Figure, that embraces his Disk, but *two*."

From this it is clear that the suggestion of *two* rings was made, not by Ball himself, but by his anonymous correspondent.

By the kind permission of the President and Council of the Royal Society, I am enabled to make the following extracts from two letters in William Ball's own hand, and likewise to give exact representations of the form of the paper-cutting, and of Ball's small sketch of *Saturn*, referred to in the foregoing Paper, both of which have been kindly copied for me by our Assistant-Secretary, Mr. Wesley.

The annexed figure shows the form of the paper-cutting.



The writing on the cutting appears to be in Oldenburg's hand.

The first letter is dated Mamhead, April 14, 1666, and is probably addressed to Oldenburg.

"I have seen ♄ two mornings this year (with a 12 foot glasse the longest I can use at this time with convenience) and find the figure the same as it was in –64. What his figure was last autumne (by mee observed with 38 foot glasse much better than that at Gresham Colledge) I suppose Sr. R. Moray hath communicated. I could not have a second sight, straining very much for that one, for the shadow of the body on his ring I doe not well understand the meaning but I suppose I saw the same thing; for I never had a clearer sight of him in any glasse I ever looked in, one thing I can boast of, sc. I am not prejudiced with any conceit of hypothesis which doth commonly send all observations to favour one side and soe there must bee a little added or diminished as the designe requires," &c. &c.

In a postscript is the following, with the little sketch:—

"I saw ♄ this morn. at 4 a clock with 12 foot glasse and judge him the same figure as in –64—that is just ovall with two black spotts and I thinke a faint shadow of a belt which I have alwaies seene, but will not be peremptory in itt."

The second letter is dated "Mamhead ♄ September 15,–66," and is addressed "For Sir Robert Moray K^{t} at Whitehall, These."

"I designe to send you all the figures of ♄. I promised them my L^{d} Brounker and hee was pleased most kindly to accept itt but I (like any thing you please to call mee bad enough) have hitherto shamfully failed, as alsoe of an account of husbandry to Mr. Oldenburg. I am still gazing at the starrs though to very little purpose more then to keep my eyes in use,"&c. &c.

It will be noticed that the passage in Ball's first letter in which he claims to be unbiased by any hypothesis, agrees with the statement of Huyghens respecting him.

The passage in the same letter, "for the shadow of the body on his ring I doe not well understand the meaning but I suppose I saw the same thing," I conjecture to refer to an attempted explanation by Huyghens, or some other astronomer, of the phenomenon observed by Ball, by attributing it to the shadow of the body of the planet cast on his ring.

It is plain that such an explanation would not be applicable, if similar depressions had been observed at the two extremities of the minor axis of the ring.

Observations of Jupiter. By W. F. Denning.

The southern equatorial belt of *Jupiter* is by far the most conspicuous feature at present visible on the surface of the planet. This belt is double, and can be readily traced as two perfectly parallel bands in all parts of the circumference except in the region immediately N. of the great red spot where it is connected at the *p.* and *f.* ends of the spot. At these points the southernmost half of the belt slopes abruptly to the N., and runs into the northernmost half, so that the great red spot now apparently lies south of a great cavity in the configuration of the dusky equatorial belts.

In the immediate region of the planet's equator, numerous dark spots and irregular patches appear from time to time, and it is important that the rotation period of these objects should be determined. They usually lie on the equatorial border of the great S. belt, and in approximately the same latitude as the permanent white spots to which so much attention has lately been given. On Oct. 26, 1882, just before daylight, I noticed a very conspicuous marking of this character slightly preceding the white equatorial spot. I re-observed this peculiar dark spot on many subsequent occasions, and recorded its times of transit across the central meridian of *Jupiter* relatively to the well-known white spot. The results show that the two objects have a common rotation period, whence we may assume that all the various markings both light and dark along the equator